FOREIGN EXCHANGE OPTIONS

by

Satyajit Das

Commonwealth Bank of Australia†

Foreign exchange options are a relatively recent innovation in foreign currency markets with important implications for the management of currency exposures incurred by organisations active in international business. This article examines the concept of foreign exchange options and a number of applications. Approaches to the valuation of foreign exchange options are also considered.

Introduction

The concept of stock options and their applications are generally well understood. Similarly, the substantial volume of activity in the spot, forward and futures market for foreign exchange testifies to their importance in international finance. Foreign exchange options are an important innovation which combine the features of an option with that of foreign exchange markets. The objective of this article is to outline the concept and application of foreign exchange options.

Foreign Exchange Options: Definitions and Concepts

A foreign exchange option is a contract which conveys the right but not the obligation to buy or sell a designated quantity of a foreign currency at a specified price (exchange rate) on or before a specified date.¹ A call (put) option in foreign exchange gives the buyer of the option the right to buy (sell) a specified amount of foreign exchange from (to) the option seller at the specified price on or before the specified date.

The exchange rate at which the option can be exercised is known as the exercise (or strike) price. The terminal date of the contract is known as the exercise (or expiration) date. If an option is capable of exercise by the holder at any time up until the expiry date, it is referred to as an American option. If the option is capable for exercise only on the specified expiry date, it is referred to as a European option.² The price paid by the buyer of an option to the seller of the option is known as the option premium.

It is necessary to distinguish between options on spot foreign exchange and options on foreign currency forwards or futures.³ Foreign exchange options on spot exchange confer the right to buy or sell the designated currency, while an option on a foreign currency forward or futures confers the right to buy or sell a forward or futures contract up to the exercise date of the option. For example, a representative contract of the later variety might include a three month option to purchase a 12 month currency forward. This article focuses mainly on options on spot exchange.

A foreign exchange option can be used to replicate (with important differences) a forward exchange contract. For example, an option to buy foreign currency in three months time is similar to a three month forward exchange contract to buy the foreign currency, except that in the case of the option the holder is not under an obligation to buy the relevant currency, at least, unless he exercises the option.

The essential economic rationale for forward exchange contracts and also foreign exchange options is their role in “insuring” against or “shifting” the risk of fluctuations in exchange rates. Consequently, an understanding of the rewards/risks attached to forward/futures contracts is important. The pay-offs to buyers and sellers of foreign exchange call and put options as well as bought and sold forward positions are set out in Exhibits 1, 2 and 3.

The differing financial characteristics of currency forwards and options are evident; gains or losses on open forward positions are limited only by movements in the exchange rate; while, in contrast, the option separates the buyer’s upside and downside risk. The purchaser of a call (put) retains the possibility of gain from a revaluation (devaluation) in the exchange rate. The net profit on a purchased call (put) equals the exchange rate’s increase above (decrease below) the option’s exercise price minus the premium. As the option is exercised only at the purchaser’s discretion, the maximum loss is limited to the premium paid when

† The views and opinions expressed are those of the author and do not necessarily reflect the views and opinions of the Commonwealth Bank of Australia.
the position is established i.e. the option operates as a limited-risk instrument. There is no comparable limitation on the risk of the option writer whose profit is limited to the premium received while his potential loss is unlimited and equals the adverse movement of the exchange rate less the premium received.

The utility of foreign exchange options derives from this limited risk feature of the instrument. A currency forward contract when it is used to “lock-in” or guarantee a fixed exchange rate on a transaction implicitly precludes the hedger from benefiting from any gain (should exchange rates move in his favour) as well as insulating the hedger from any loss (if exchange rates move in an unfavourable direction). Foreign exchange options, in marked contrast, enable the hedger to limit the risk of any loss but do not preclude him from benefiting from any gain resulting from fluctuations in exchange rates. This, for example, would enable an importer (exporter) to fix a maximum (minimum) price for buying (selling) foreign currency without preventing him from benefiting from a decline (increase) in the value of the foreign currency relative to the local currency. Foreign exchange options, thus overcome a significant deficiency of conventional currency forward or futures contracts enabling users to limit risk without the need to sacrifice.
possible profits from favourable movements in the exchange rate.

**Foreign Exchange Options: Applications Hedging Foreign Exchange Exposures**

Foreign exchange options can be used to hedge against exchange exposures incurred in international transactions, as the following examples illustrate:

1. In September, an Australian importer becomes aware of a requirement to make a payment in US dollars (USD) in December. The spot exchange rate for Australian dollars (AUD)/USD is : AUD 1.1236/USD1.00. The three month forward rate is: AUD 1.1292/USD1.00 (a premium of 0.0056). The importer buys a December call option for a premium of AUD 0.0055 to buy USD at an exercise price of AUD 1.1292 per USD.

   If in December, the AUD/USD exchange rate is above the exercise price say, for example, 1.1798 (a 5 per cent devaluation of the AUD) the importer will exercise the option to lock in the lower purchase price of the USD. If the exchange rate is below the exercise price say, for example, 1.0674 (a 5 per cent revaluation of the AUD) the importer would let its call option expire, and buy USD on the market at the lower price. In this particular example, the effective cost of USD to the importer would have been 1.0729 (spot price plus the premium).

   In this example, the importer considers an option on spot exchange. However, he could equally consider a one month option to purchase a two month forward/futures contract which becomes spot exchange or its equivalent in December; i.e. utilise an option on a currency forward or futures as distinct from an option on spot exchange to cover his exposure.

2. Conversely, an Australian exporter expecting USD receipts would have hedged by buying a December put option for a premium of AUD 0.0055 to sell USD at an exercise price of AUD 1.1292 per USD. If in December the AUD/USD exchange rate is 1.1798 i.e. above the exercise price the exporter will abandon the option and sell USD on the market for the higher AUD equivalent, achieving an effective price of 1.1743 (spot price less the premium). If the exchange rate is 1.0674, i.e. lower than the exercise price, the exporter would exercise the option to sell USD at the higher price.

   The result of the alternative hedging strategies may be summarised as in the table below.

   The results highlight the use of foreign exchange options to establish the maximum cost (minimum receipts) for a foreign currency payable (receivable) without precluding the possibility of gaining from favourable movements in the exchange rate.

   Currency forwards may be combined with foreign exchange options to achieve identical results (the critical variable here is the relative cost of put versus call options) to those outlined above. For example, the importer (exporter) could, as an alternative to purchasing call (put) options, have bought (sold) USD forward to December, while simultaneously buying put (call options) to lock-in the right to effectively close out or offset the forward currency position at a specified rate.

   It is important to note that the decision to hedge using foreign exchange options is not independent of expectations of the future exchange rate. Foreign exchange options based hedges should only be the preferred exposure management strategy where there is considerable upside potential as well as downside risk. Where only downside risk is perceived, a

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AUD/USD Exchange Rate</strong></td>
<td><strong>AUD/USD Exchange Rate</strong></td>
</tr>
<tr>
<td>Devalues to 1.1798</td>
<td>Revalues to 1.0674</td>
</tr>
<tr>
<td>1,129,200</td>
<td>1,123,700</td>
</tr>
<tr>
<td>1,134,700</td>
<td>1,072,900</td>
</tr>
</tbody>
</table>

JASSA/1984, No. 3 (October)
conventional hedge using currency forwards is likely to be superior because of the extra cost of the option.

Foreign exchange options are, in addition to their utility in hedging normal foreign currency denominated receivables and payables, of particular relevance to contingency hedging situations. For example, where an organisation is uncertain of its foreign currency receipts (payments) e.g. when a transaction falls through, when a bid on a foreign currency contract is accepted or rejected, or when expected interest or dividends exceed (or fail short of) the expected amount — at a time when exchange rates are expected to move adversely, a forward currency transaction could be undertaken but if the expected inflow (or outflow) fails to materialise or is substantially different in amount from that expected, the hedger would, given the fixed and inviolable nature of forward contracts be left with a currency exposure. In contrast, a hedge strategy utilising options — because it conveys the right but not the obligation to buy or sell the currency — provides a relatively low cost, flexible instrument for covering an uncertain commitment.

Consider the hypothetical example (outlined previously) of the export hedge. If the expected receipt does not eventuate, the exporter could, on the facts concerned, gain if the AUD revalued or lose if the AUD devalued. In contrast, purchase of a foreign exchange put option for a fixed maximum cost of AUD5,500 per USD million could provide the required protection. Moreover, the foreign exchange option, would merely set the minimum selling price for USD received with the exporter having the opportunity to benefit if the AUD devalued. Foreign exchange options thus provide an effective means of hedging tenders or bids which may result in foreign currency denominated receipts on a future date with the option being added to the price of the bid as an insurance cost (although strictly speaking the option price reflects hedging and investment values as well as an insurance component).

**Investment Applications**

In addition to their hedging applications, foreign exchange options can constitute a versatile investment enabling investors or speculators to profit from anticipated movements in exchange rates with limited risk (the maximum amount the investor can lose is the cost of the option). For example, an investor anticipating a rise (fall) in exchange rates can realise substantial profits by buying a call (put) option if the expected movement occurs. A number of limited risk investment strategies involving combinations of options are also feasible: e.g. straddles, a put and a call on the same currency at the same exercise price and for the same exercise periods; spreads, the simultaneous purchase and sale of two options of the same type (put or call) with the same exercise price but differing maturity dates (a time spread) or with the same maturity dates but differing exercise prices (a vertical spread).

Traders utilise such strategies to capitalise on a situation where one option is over or undervalued in relation to another, to take positions on the expected volatility of a currency and to maximise returns on investment while reducing the risk associated with an outright bought or sold position.

**Writing Foreign Exchange Options**

Options are written for the primary purpose of realising premium income. Unlike a buyer of an option who, for the outlay of the premium, obtains a limited risk investment or hedge cover from adverse movements in the exchange rate, the writer takes on, in exchange for the premium, a significant potential risk of loss which, moreover, is not limited except where, as discussed below, the option is covered and consequently the risk to the writer is limited. Foreign exchange options may be either covered, that is written against an opposite position in the spot and/or forward currency market; or naked, written without an opposite spot or forward position. Writers of foreign currency options will generally be organisations involved in foreign currency trading who have commitments to buy or sell foreign currencies and may write options as a means of obtaining a satisfactory selling price or "grossing-up" returns on holdings of the relevant currency.

For example, an Australian firm which as part of its operations maintains a portion of its liquid funds in USD may, in order to generate additional income on its USD holdings, write call options on some portion of those holdings. Thus, in exchange for the receipt of the premium, the firm must be prepared to deliver USD at the exercise price specified in option contract. The firm would, in effect, be generating income for which it would forego the opportunity to benefit from significant increases in the value of USD relative to AUD. The premium received can be treated either as incremental income or as a partial hedge or cushion against small movements in the value of a currency.
Arbitrage Opportunities

Foreign exchange options have a number of arbitrage links to both spot and forward markets in the relevant currency. The basic relationships, which are outlined by Giddy (1983), between the physical currency market rates and the premium on options derive from the various combinations of options, forward contracts and lending and borrowing which can be used to replicate one another. Techniques such as a conversion (buying a put, selling a call, and engaging in a forward contract to buy the currency on the option expiry date) or a reversal (the reverse of a conversion) are the basis of conducting arbitrage activities between the options and the forward currency markets. The arbitrage relationships must hold continuously, not just on the expiry date, as the options (whether American or European) can be traded up to expiry, and discrepancies between markets give rise to feasible and profitable opportunities for arbitrageurs.

Valuation of Foreign Exchange Options

The option premium at a particular time, and increases and decreases in the premium, are the major determinant of the effectiveness of hedging and investment strategies utilising foreign exchange options. In a sense, the primary determinant of option premiums is supply and demand: option premiums must be high enough to induce sellers to write them and low enough to induce buyers to purchase them. However, it is clearly possible to further analyse the fundamental determinants of option premiums and the principal factors that influence them.

It is necessary to distinguish between the intrinsic value and the time value of a foreign exchange option. An option’s intrinsic value is based on the difference between its exercise price and the current price. If an option is currently profitable to exercise, it is said to have intrinsic value, e.g. a call (put) option has intrinsic value if the current exchange rate is above (below) the option’s exercise price. Whether or not the option has intrinsic value, it may have time value (the excess of the premium over the option’s intrinsic value) reflecting the possibility that at some time prior to expiration, it may become profitable to exercise.

Most valuation models for options make use of the concept of a riskless portfolio containing an option and the underlying commodity. The portfolio is continuously adjusted to ensure that the underlying security and the option are held in the proportion whereby price movements in one are offset by opposite price movements in the other — i.e. risk is eliminated. As in equilibrium, riskless portfolios will not return in excess of the risk-free rate of return, the risk free portfolio may be used to derive a theoretical value of the option. This approach requires additional assumptions including: efficient, frictionless capital markets, and that changes in currency values follow a log-normal distribution with constant variances as well following a continuous stochastic process (i.e. there are no “jumps”). While clearly these assumptions may not strictly hold in reality, valuation models built upon them can provide useful approximations of an option’s value.

The Black-Scholes (1973) stock option pricing model, as adapted by Black (1976), can be used to derive the value of a currency call option:

\[
C = e^{-rT} \left[ F \cdot N(d_1) - E \cdot N(d_2) \right]
\]

\[
d_1 = \frac{\ln(F/E) + \left(\frac{1}{2}V^2\right)T}{\sqrt{T}}
\]

\[
d_2 = d_1 - \sqrt{T}
\]

where: \(C\) is the price of a European call option; \(F\), the price of the currency i.e. the exchange rate on the relevant currency to be delivered at option maturity; \(E\), the exercise price of the option; \(V\), the volatility of the currency price \(F\); \(r\), the risk free interest rate continuously compounded; \(T\), the time remaining to maturity of the option; and \(N(d)\), the cumulative normal profitability density function.

The intuition behind the Black adaption of the original Black-Scholes model is that: firstly, investment in a forward contract requires no commitment of funds (deposit costs, etc. are ignored) whereas investment in the physical commodity imposes a cost; and secondly, the value of a call option on a forward contract should be lower than the value of a call option on the physical commodity, since the forward price should already impound the carrying cost associated with the physical commodity.

The price of a put option can be derived utilising put-call parity. For European currency options:

\[C - P = (F - E)e^{-rT}\]

where: \(P\) is the price of a European put option.

The valuation model highlights the five variables that affect the price of foreign exchange options. The variables and their effect on the value of an option...
(where all other variables are held constant) can be summarised as follows:

<table>
<thead>
<tr>
<th>Increase in</th>
<th>Affect Upon Call Option Price</th>
<th>Affect On Put Option Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Exchange Rate</td>
<td>Increase</td>
<td>Decrease</td>
</tr>
<tr>
<td>Exercise Price</td>
<td>Decrease</td>
<td>Increase</td>
</tr>
<tr>
<td>Risk Free Rate</td>
<td>Decrease</td>
<td>Decrease</td>
</tr>
<tr>
<td>Time to Expiry</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Volatility</td>
<td>Increase</td>
<td>Increase</td>
</tr>
</tbody>
</table>

Volatility or variance in the underlying exchange rate is a critical determinant of the option value and it is also the only factor not directly observable. Volatility measured over past periods is generally used as a proxy for variance over the life of the option.

However, the adapted Black-Scholes option pricing model may not apply well to foreign exchange options, since several interest rates are involved in ways differing from the assumptions of the Black-Scholes model. Garman and Kohlhagen (1983) argue that it is the interest rate differential (between foreign and domestic rates) that reflects the expected price drift of the underlying asset rather than a single interest rate which is appropriate to represent drift in a simple commodity option. Garman and Kohlhagen derive the following valuation formula:

\[
C = e^{-rT} S N\left(x + \sqrt{V} \right) - e^{-rT} E N\left(x\right)
\]

where: \( C \) is the price of a European call option; \( S \), the spot price of the deliverable currency; \( E \), the exercise price of the option; \( V \), volatility of the spot currency price; \( rf \), the foreign risk free interest rate; \( rd \), the domestic risk free interest rate; \( T \), time remaining until maturity of option; and \( N(d) \), the cumulative normal density function.

The price of the equivalent European put is given as:

\[
P = e^{-rfT} S \left[ N\left( x + \sqrt{V} \right) - 1 \right] - e^{-rdT} E \left( N(x) - 1 \right)
\]

where: \( P \) is the price of a European put option.

The difference between the two valuation approaches gains importance when \( rf \) — \( rd \) is small and \( rd \) is large (or vice versa) and problems of option mispricing are concerned.

In terms of the Garman-Kohlhagen valuation model, when other variables are held constant, the value of a European call option rises when the domestic interest rate increases and falls when the foreign interest rate increases. Increases in volatility uniformly give rise to increases in the option price, while increases in the exercise price cause call option prices to decline. The impact of increases in the time to maturity of the option is, however, ambiguous and it is necessary to proceed on a case-by-case basis taking into account the values of the other inputs in the valuation process.

The approaches to valuation considered focus on pricing European options. It is important to note that if all other factors are identical, an American option is at least as valuable as and generally never less valuable than an European option because the owner of an American option has every right — and more — that the owner of the corresponding European options have.

The European option valuation formulas discussed will not adequately price American foreign exchange options as the possibility of early exercise is an important factor in valuing an American option. Grabbe (1983) shows that for sufficiently high (low) value of the spot rate relative to the option exercise price, American calls (puts) will be exercised prior to maturity and hence, for positive interest rates, American foreign exchange options will have values strictly greater than equivalent European options. In particular, an American option is subject to different boundary conditions to that of its European counterpart in that the price of an American option can never be less than the immediate conversion value. Approximate solutions for American foreign exchange options may be found using numerical methods (similar to those used to value American put options on stocks).

The Market for Foreign Exchange Options

Listed options on foreign currencies (including Pound Sterling, Canadian Dollars, Deutschemarks, Yen and Swiss Francs against the USD) are traded on the Philadelphia Stock Exchange. Foreign exchange options are also traded on other exchanges including Montreal and Amsterdam. The International Monetary Market of the Chicago Mercantile Exchange also began trading in options on Deutschemark. The Chicago option differs slightly from, for example, the options traded at Philadelphia, in that it is an option on a futures contract rather than spot currency.

Alongside the exchange traded options markets, a substantial over the counter ("OTC") dealer market dominated by US commercial and investment banks
Foreign Exchange Options

(where the options — often customised — are purchased from an institution that buys and sells the instrument) has also developed. Customised OTC options are less liquid than exchange traded options lacking a readily available secondary market and pricing is at the discretion of the writer. The OTC and exchange traded markets are, however, increasingly integrated with OTC option writers covering their position through exchanges such as Philadelphia.

The Sydney Futures Exchange (SFE) introduced a commodity options facility on its USD contract in March 1982. The SFE options (which are American options) have not been as successful as expected for a number of reasons. A lack of understanding of foreign exchange options and the absence of option writing interest has clearly impeded development of the market. The fact that the SFE USD futures contract does not have the depth and liquidity of the currency hedge market (until now the principle avenue for hedging currency exposure in Australia) has also limited the scope for development.

A major reason for the lack of interest in the SFE facility appears to have been the fact that the options contract as presently constituted requires an option, once taken, to be either exercised or allowed to lapse with transfer to a third party not being allowed. This is in contrast to options on futures in the US where such options are freely traded, prior to expiry, on the relevant exchanges. In the US, a significant proportion of holders do not, in fact, exercise the options to take positions in the currency market but choose rather to simply buy or sell an offsetting option, realising their profit or loss from the increase or decrease in option premiums.

Summary and Conclusions

Foreign exchange options represent an important innovation in international financial markets. The potential utility of options for Australian organisation depends on the emergence of a competitive and liquid market in AUD focused option instruments. There is increasing interest by local financial institutions (particularly the subsidiaries of major US banks such as Bank of America and Citibank) in an inter-bank or over-the-counter market for foreign exchange options. As developmental problems are overcome, with increased appreciation by potential users of the scope and value of the markets concerned, foreign exchange options appear likely to emerge as an important currency exposure management alternative for corporate treasurers and portfolio managers.

July 1984

Footnotes

1. A forward exchange contract where only the date of execution is at the buyer’s (or seller’s) choice is often mistakenly referred to as an option.

2. Foreign exchange options traded on organised exchanges are invariably American options; dealer options, in some cases, are European options.

3. There is little substantive or functional difference between a forward currency contract and a currency futures contract except that the latter is a standardised instrument, traded for delivery on specified dates and rarely settled by delivery of the underlying amount of the relevant foreign currency; throughout this paper, the terms are used interchangeably.

4. Bid-ask spreads as well as transactions costs, etc. are ignored for ease of exposition.

5. The data utilised for the examples are hypothetical.

6. For a more detailed discussion of approaches to option pricing: see, for example, Copeland and Weston (1983) Chapter 8.

7. In the case of an option on a currency forward or futures; F is the current forward exchange rate or futures price; and S the volatility of the underlying forward/futures rate.

8. The Black-Scholes option pricing model employs the interest rate in two different contexts: firstly, to discount future values; and secondly, as an arbitrage-based surrogate for the drift of the deliverable instrument. The first use always takes place outside of the function N (.), while the second takes place inside, reflecting the distribution of maturation values. Garman and Kohlhagen show that it is only the interest rate differential which controls the distributional features, while the interest rates themselves control the discounting of future values.

JASSA/1984, No. 3 (October)
9. Garman and Kohlhagen show that by substituting the forward price of currency deliverable contemporaneously with the maturation of the option (using the familiar interest rate parity condition that the forward exchange premium equals the interest differential) into their valuation model, it is possible to derive the Black commodity option pricing model, showing that foreign exchange options may be treated on the same basis as commodity options generally, provided the contemporaneous forward instruments exist.

10. Salomon Brothers, for example, recently sold warrants — essentially a longer-maturity foreign exchange option — to buy or sell Sterling and Deutschemark [see Reier (1984)].

11. The SFE are apparently considering changes to the contract to make the options fully tradeable.

12. The examples utilised in this paper assumes, for ease of exposition that the options are exercised; similar results would, however, have been obtained had the transactions been closed out by simply buying or selling the option.


Selected References
Tamir Agmon and Rafael Eldor “Currency Options Cope with Uncertainty” in Euromoney (May 1983), pp 227, 228. 
Sydney Futures Exchange Ltd. “Commodity Options” (December 1982).